THE POWER of VOLTAMMETRY

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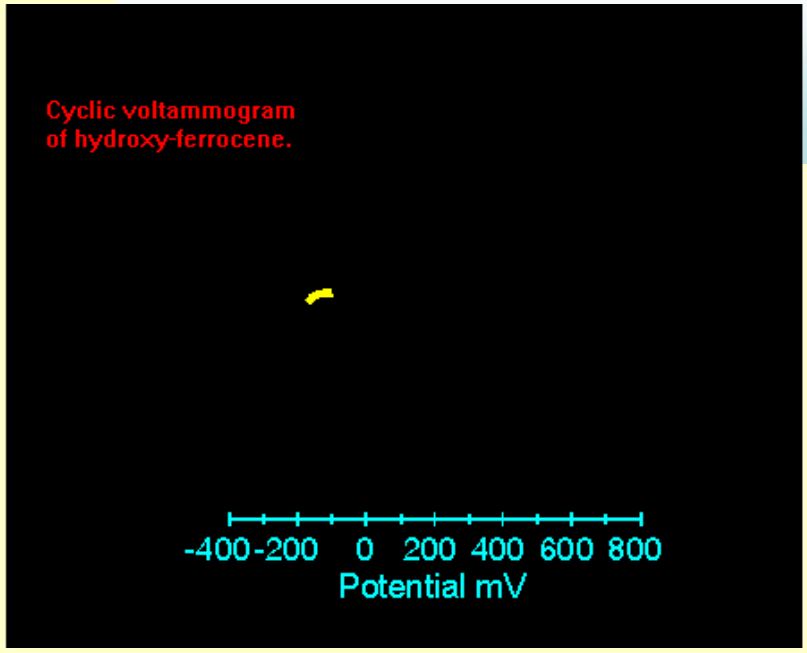
Goce Delcev University, Stip, Macedonia

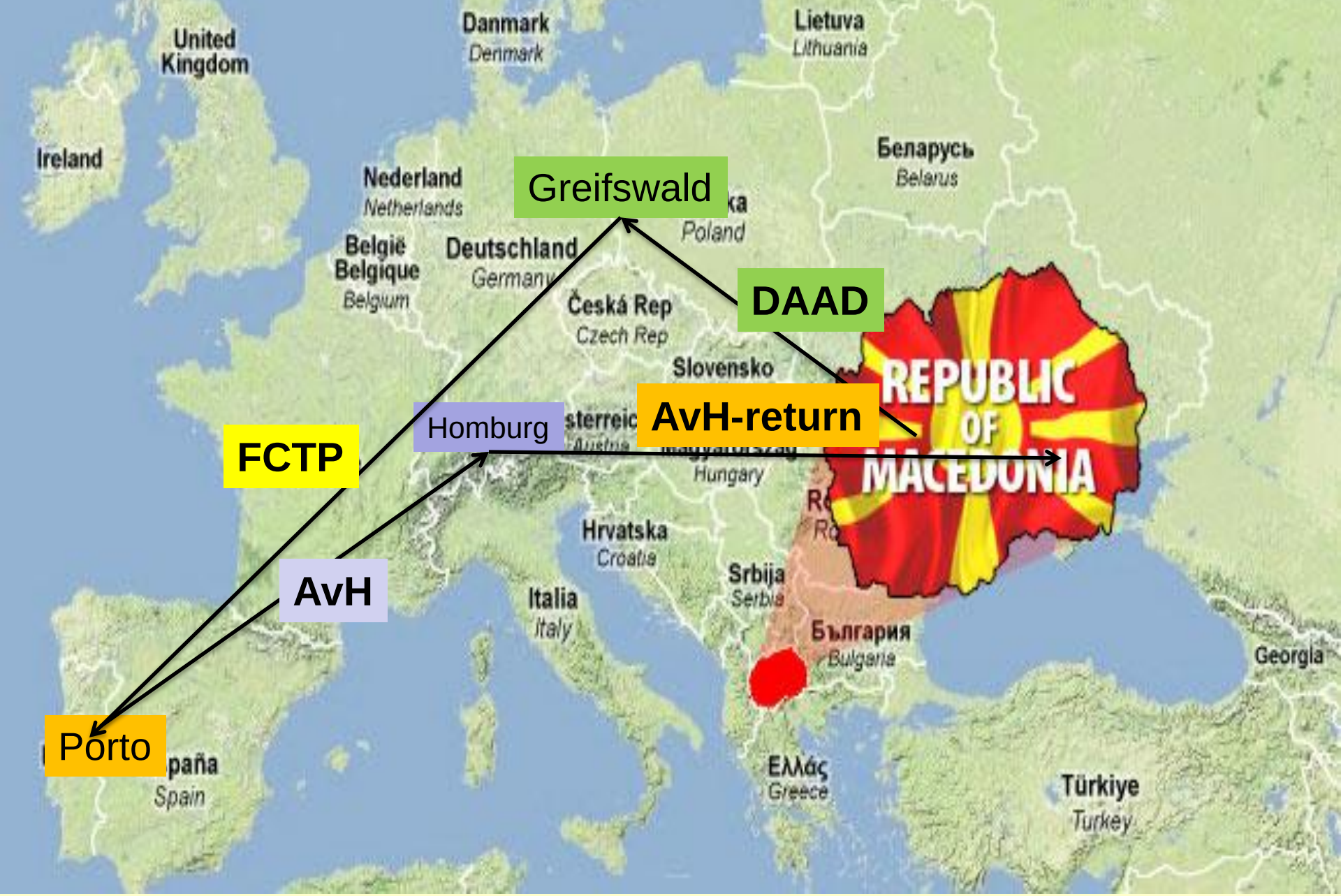


Alexander von HUMBOLDT KOLLEG
Macedonia 19-23 April
OHRID

…at the door of EU

Goce Delcev University, Stip MACEDONIA

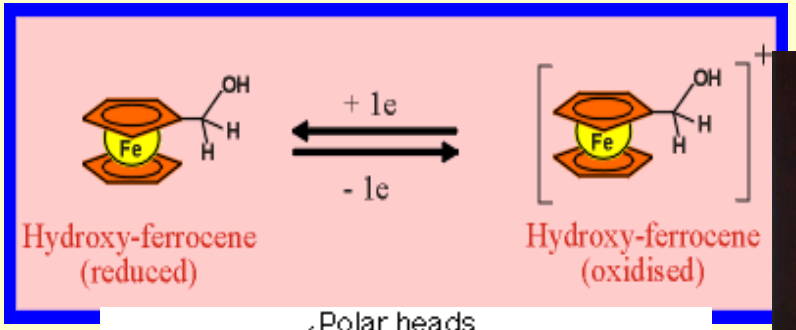
“HUMBOLDT ALEE” at the Institute of Chemistry, SKOPJE----why?

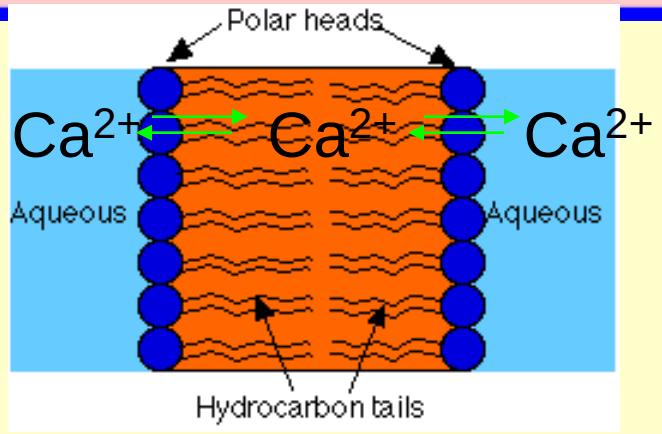

Greifswald
DAAD
AvH-return
Homburg
FCTP
AvH
Porto
REPUBLIC OF MACEDONIA
United Kingdom
Ireland
Danmark
Denmark
Lietuva
Lithuania
Беларусь
Belarus
Nederland
Netherlands
Poland
België
Belgique
Belgium
Deutschland
Česká Rep
Czech Rep
Slovensko
Hungary
Hrvatska
Croatia
Srbija
Serbia
Italia
Italy
България
Bulgaria
Georgia
Ελλάς
Greece
Türkiye
Turkey
Spain

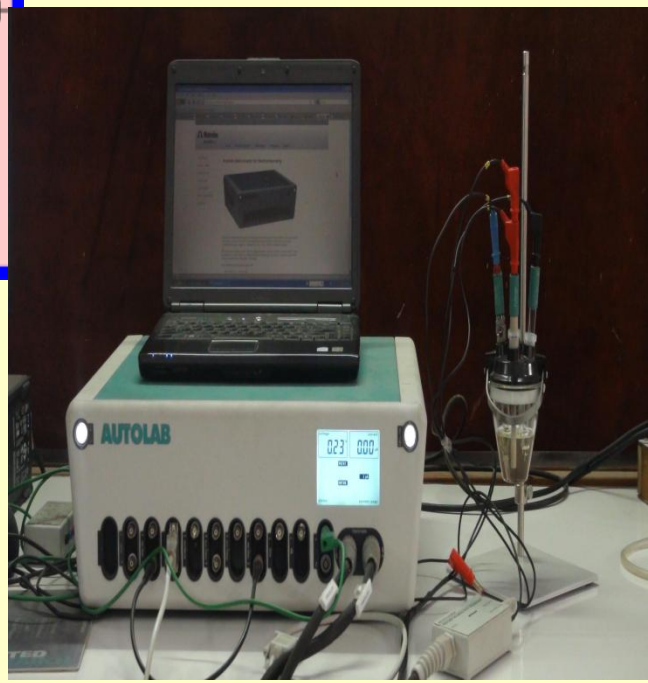
VOLTAMMETRY is a branch of *ELECTROCHEMISTRY*

-deals wity the processes of CHARGE transfer between two systems

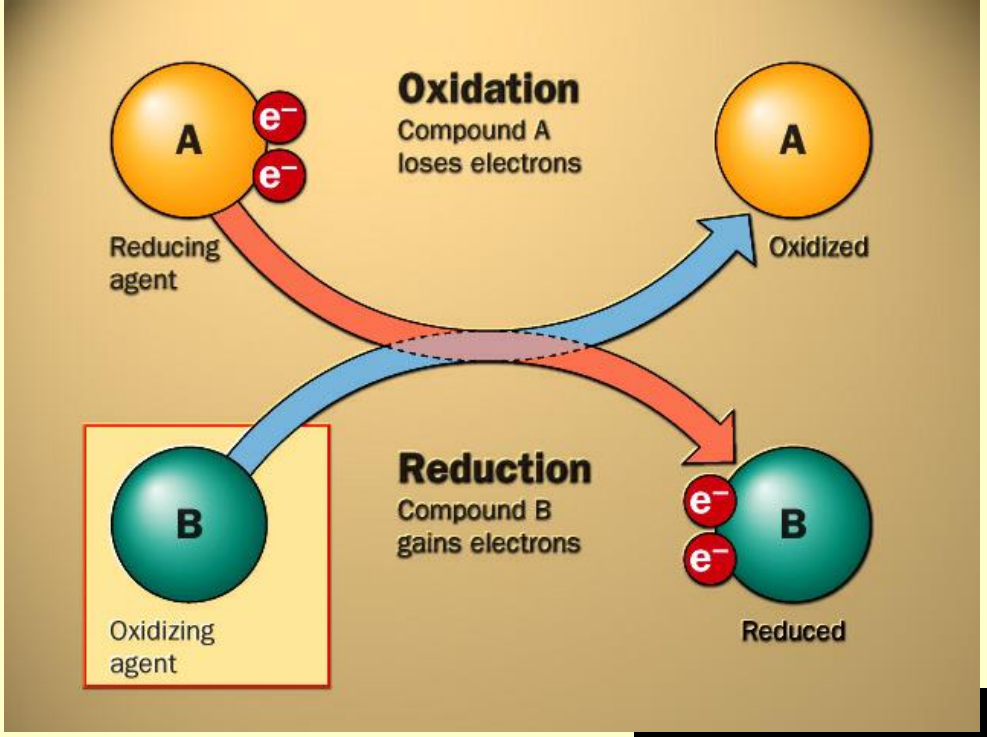
-FLOW of electric charge=CURRENT

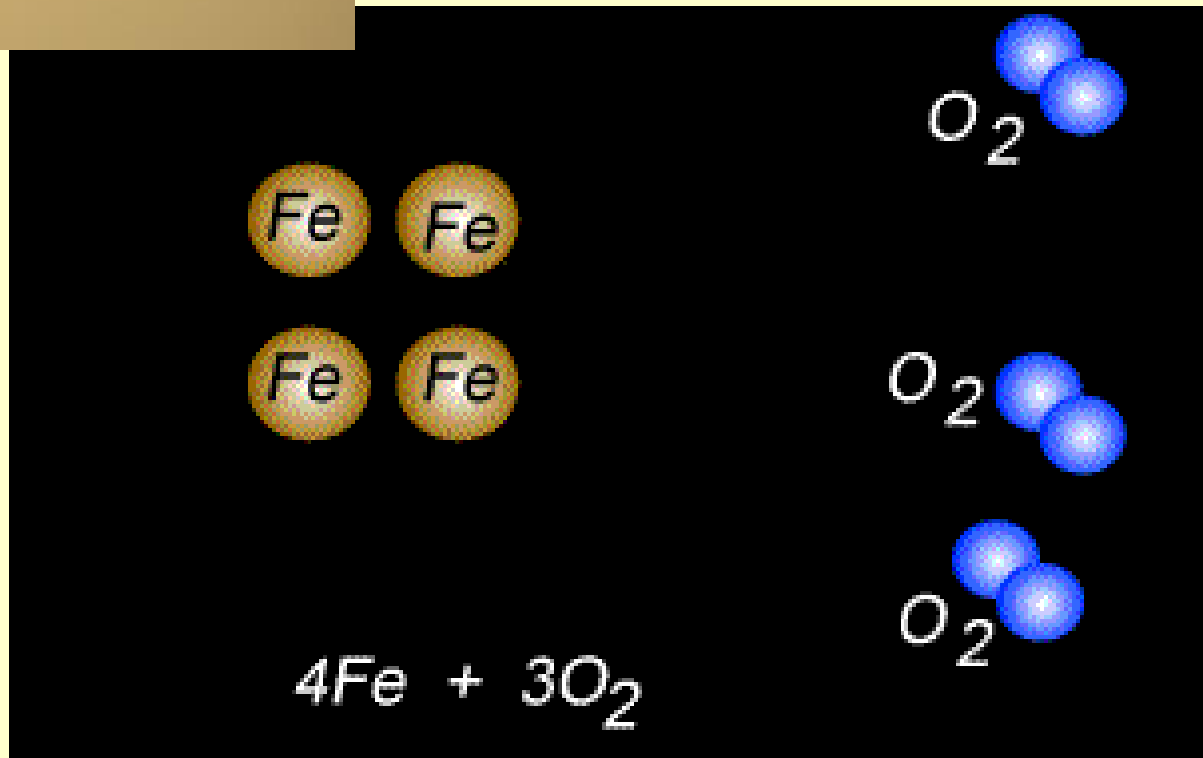




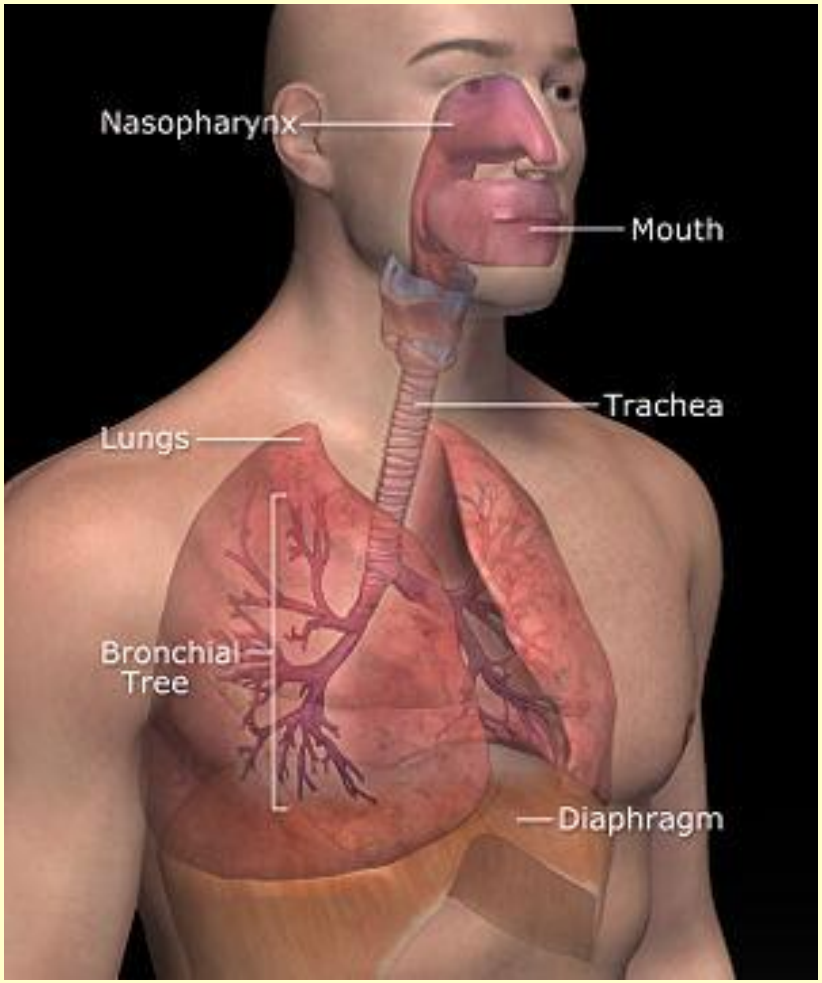


We can say-voltammetry deals MAINLY with Processes of oxidation and reduction

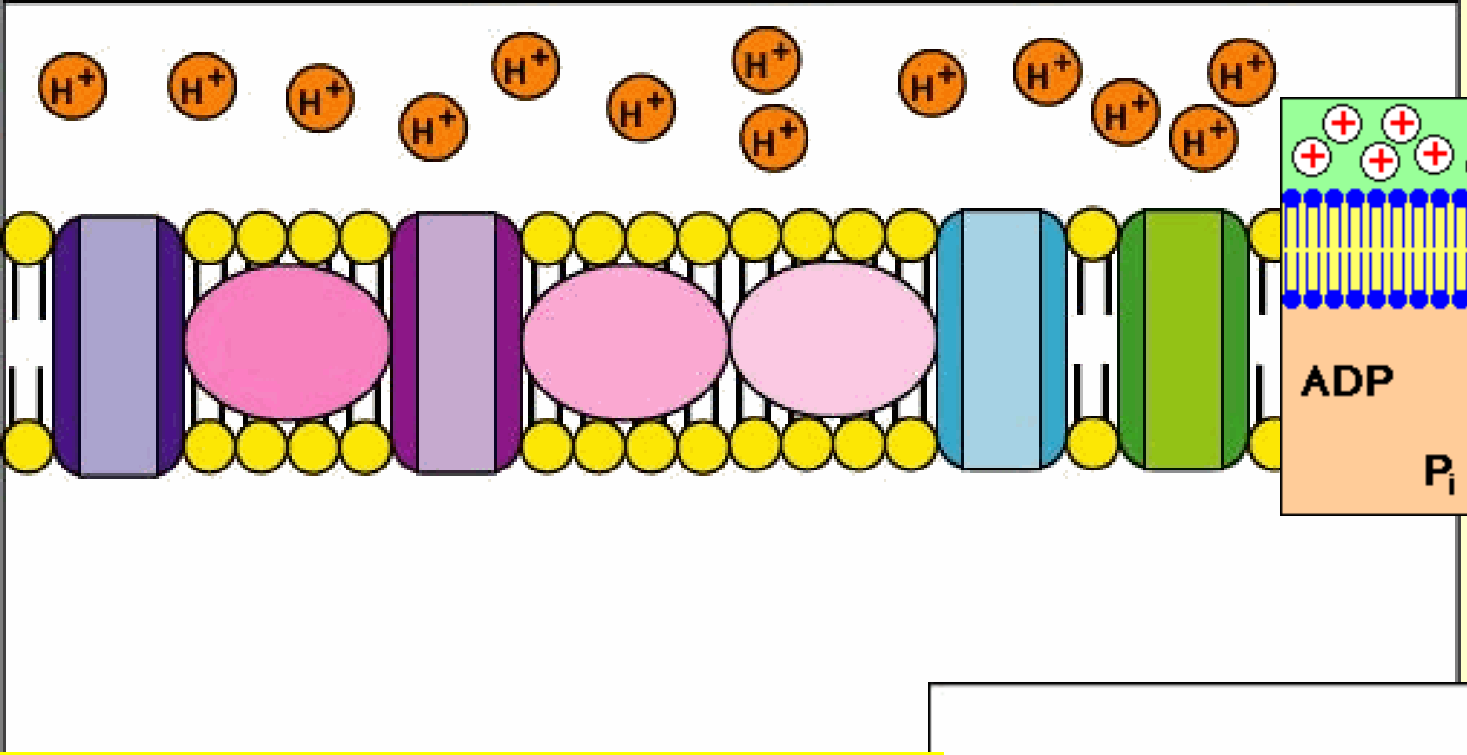

A
e⁻
e⁻
Oxidation
Compound A
loses electrons
A
Reducing
agent
Oxidized
B
Reduction
Compound B
gains electrons
e⁻
e⁻
B
Oxidizing
agent
Reduced

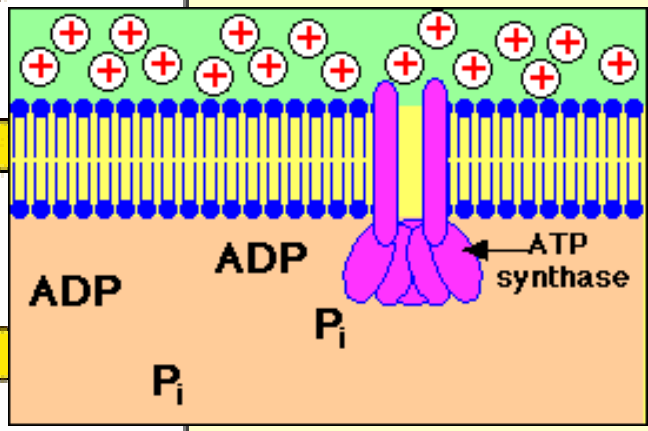

Fe
Fe
Fe
Fe
O2
O2
O2
4Fe + 3O2

Milions of processes in living Systems have oxidation-reduction nature

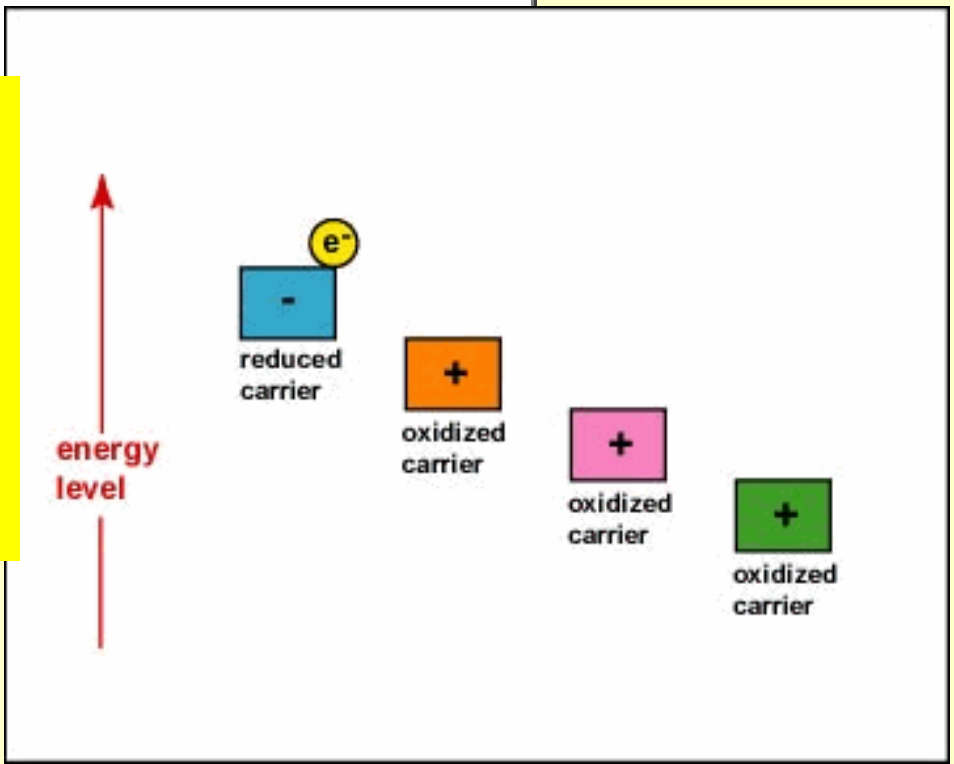


$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 2880\ kJ/mol$$



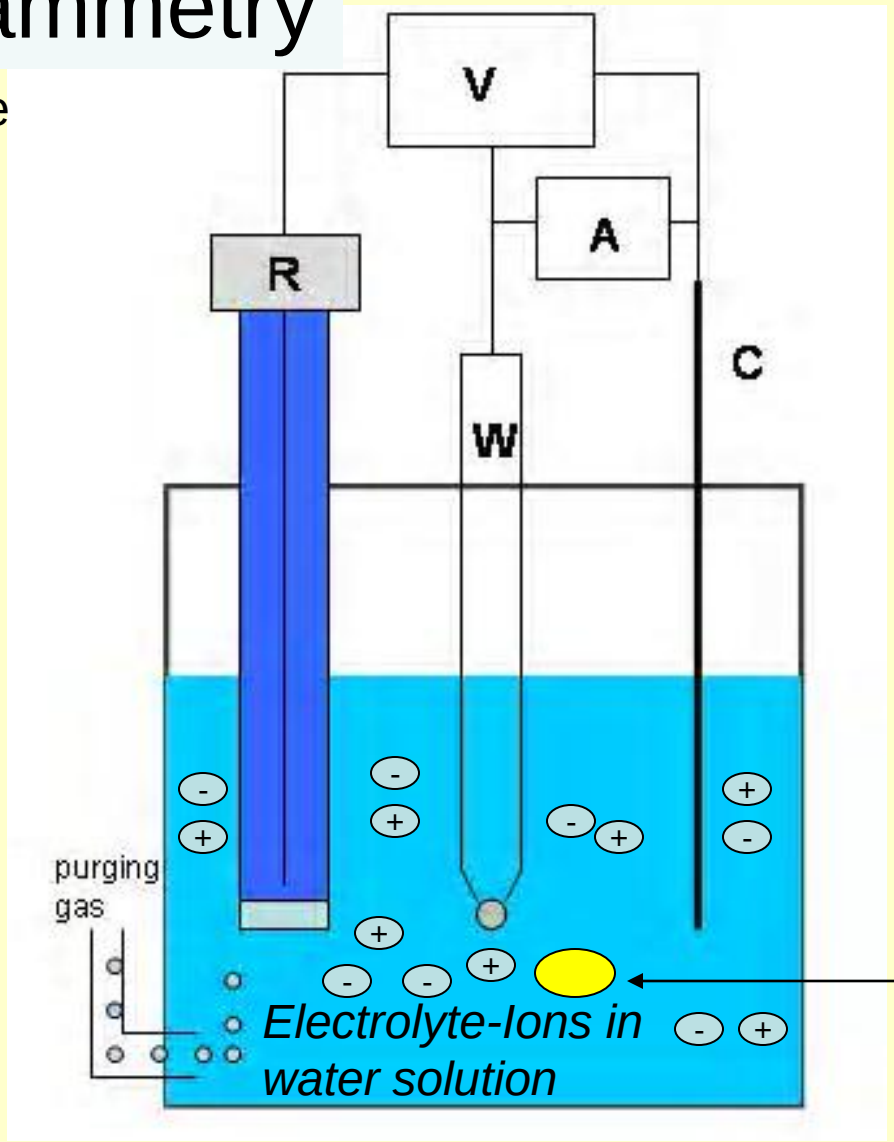


The Electron Transport Chain
CREATION OF ATP
From FOOD is, indeed
the most important
Electrochemical process
in living systems

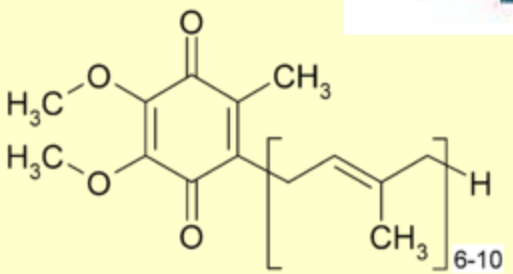


Voltammetry

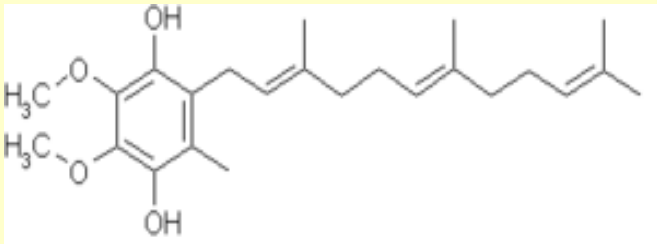
W-working electrode

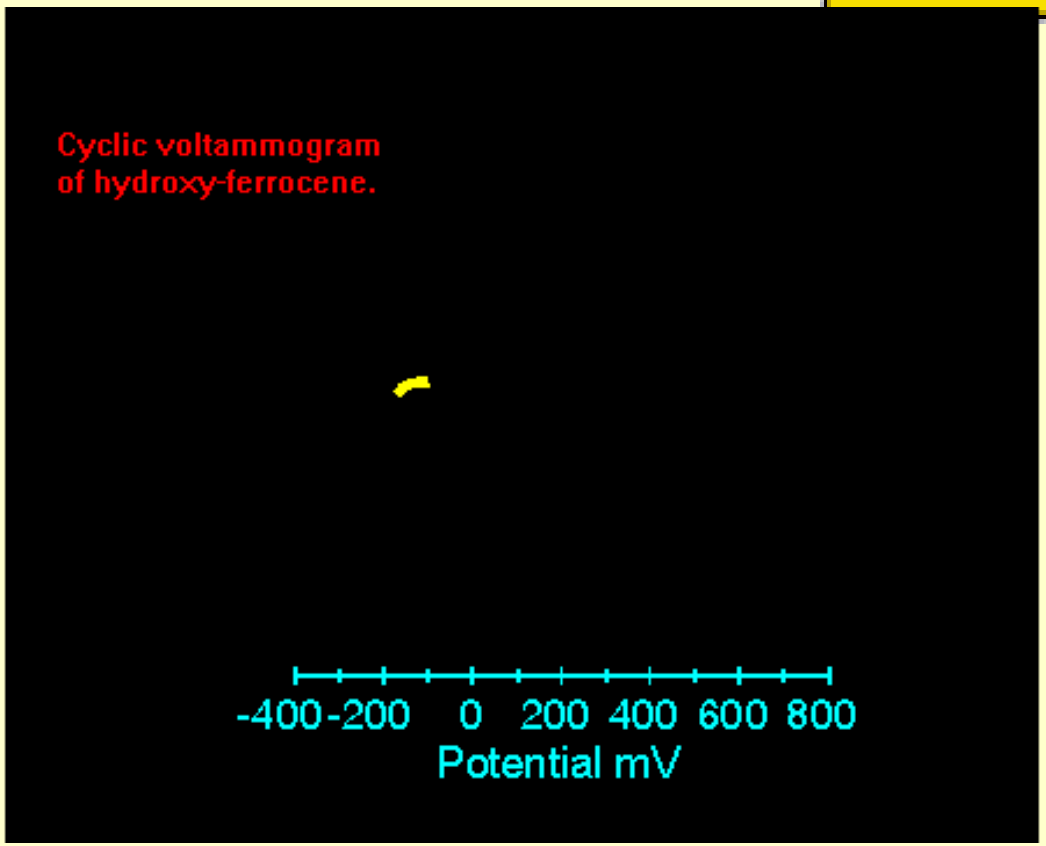


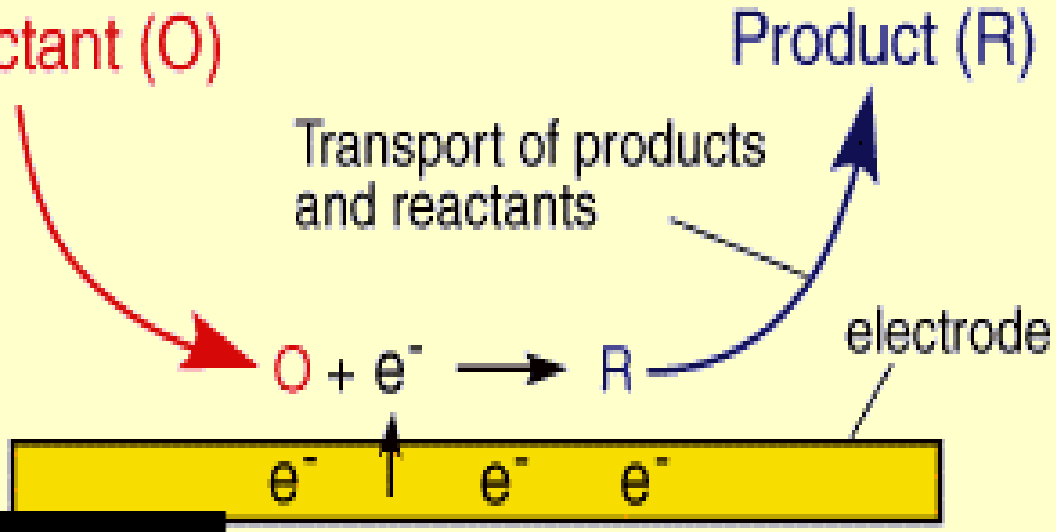
R-reference electrode



+2 H+ + 2e- ⇌




Cyclic voltammogram
of hydroxy-ferrocene.
-400 -200 0 200 400 600 800
Potential mV

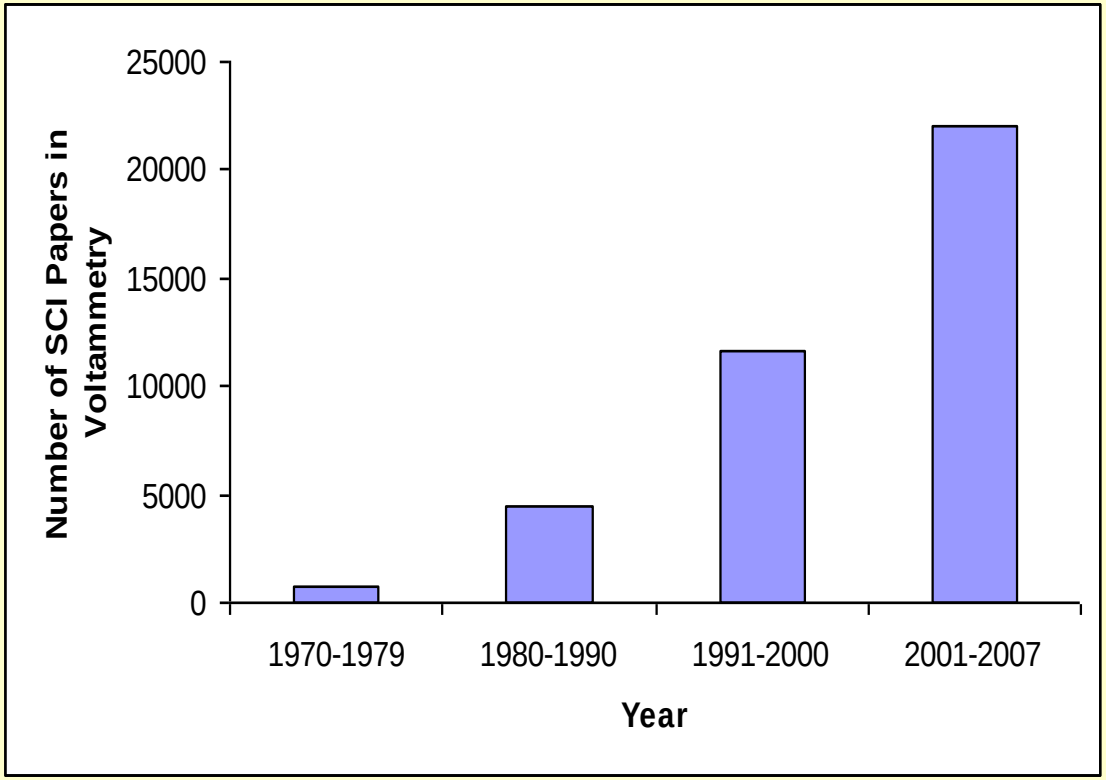

Reactant (O)
Product (R)
Transport of products
and reactants
O + e⁻ → R
electrode
e⁻ e⁻ e⁻

Application of the Voltammetry

-In Chemistry, Physics and Engineering

-In Biology and Biochemistry (biosensors)

-In Pharmacy



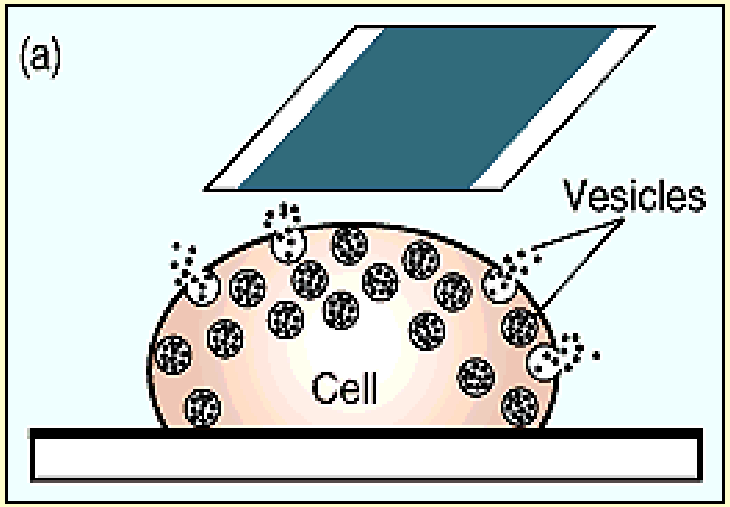
-In Medicine

-detection of reactive radicals nitroxides, superoxides,...

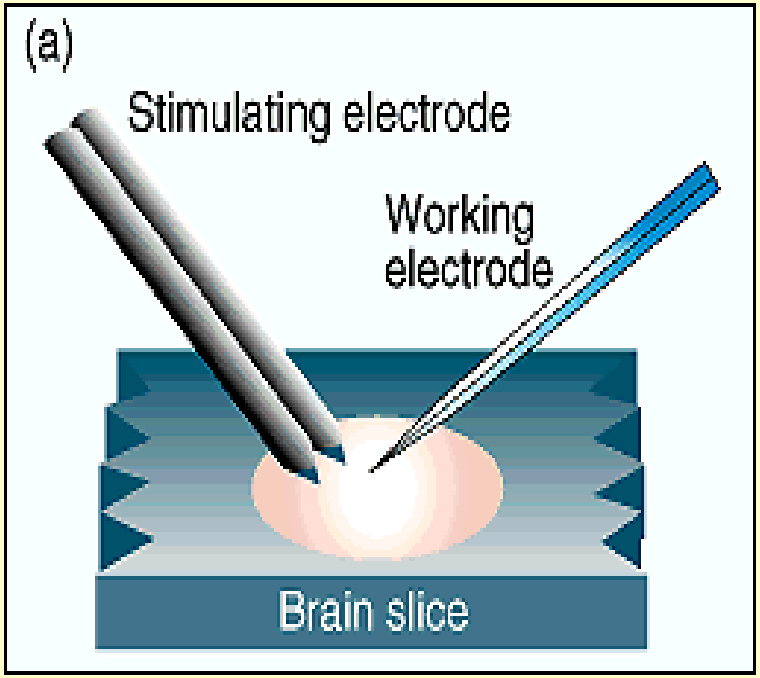
-determination of various active compounds

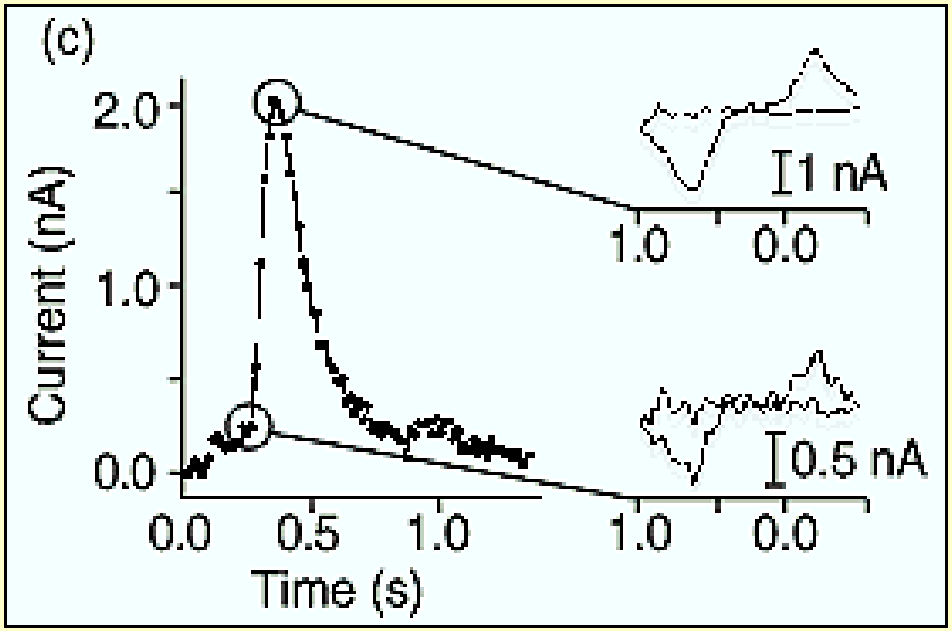
-following of protein-protein interactions

-medical sensors for various electron cariers and neurotransmiters



IN-VIVO voltammetric determination of catecholamine

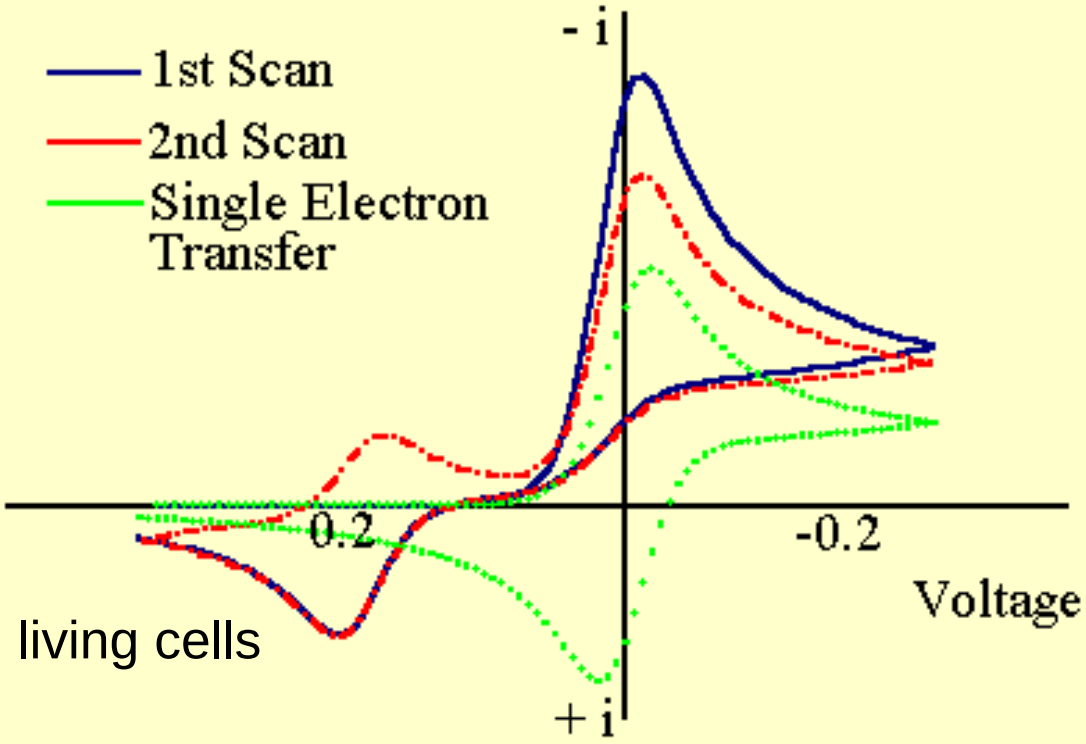




What kind of information can provide Voltammetry?

-Mechanism pathway

-detection of the **intermediates** and final products of the redox reactions



Peroxyde nitrite oxidation in living cells

ONO_2^- - e- = $ONO_2^{\cdot}$...NO_2^-

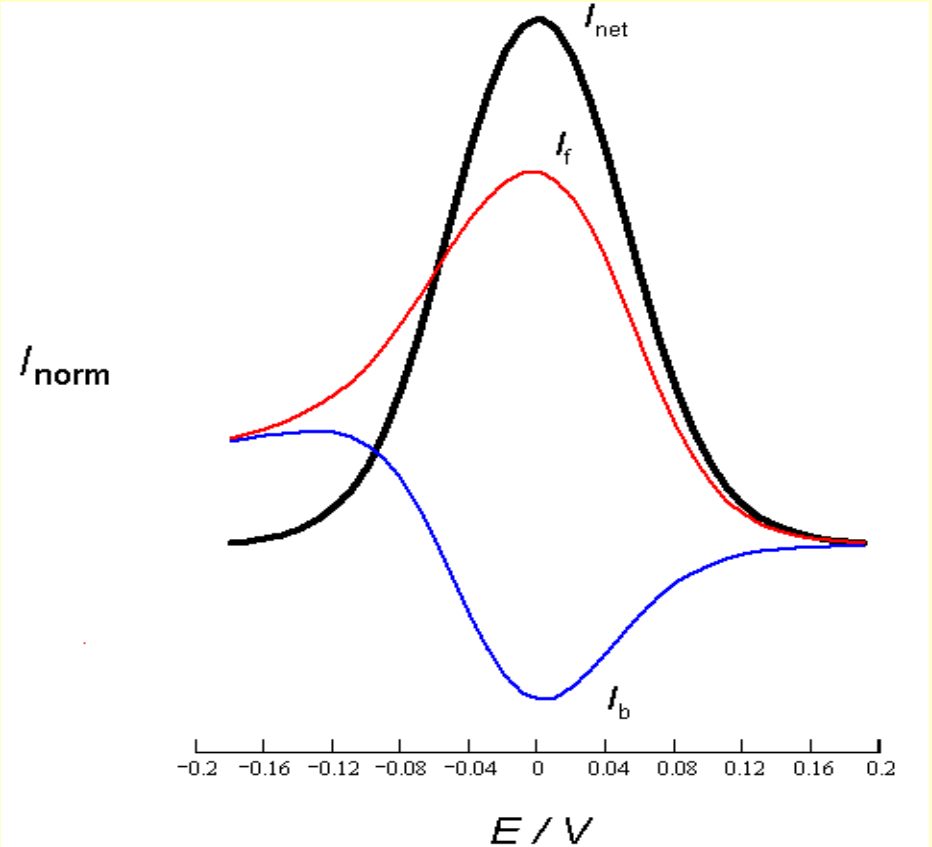
NO_2^- + 2OH- -2e- = NO_3^- + H_2O

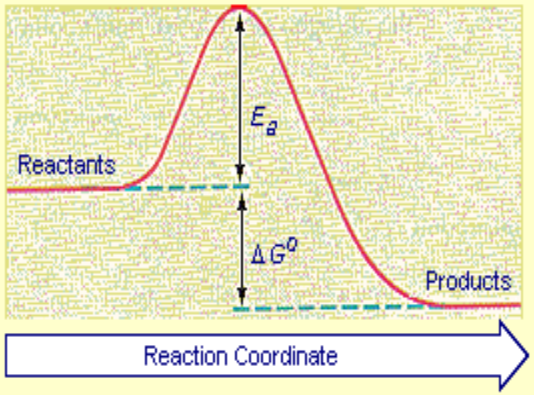
-Thermodynamic Parameters of Redox Reactions

***Standard Redox Potential**-Energy of Activation*., Enthalpy, **Complexation Constants**...

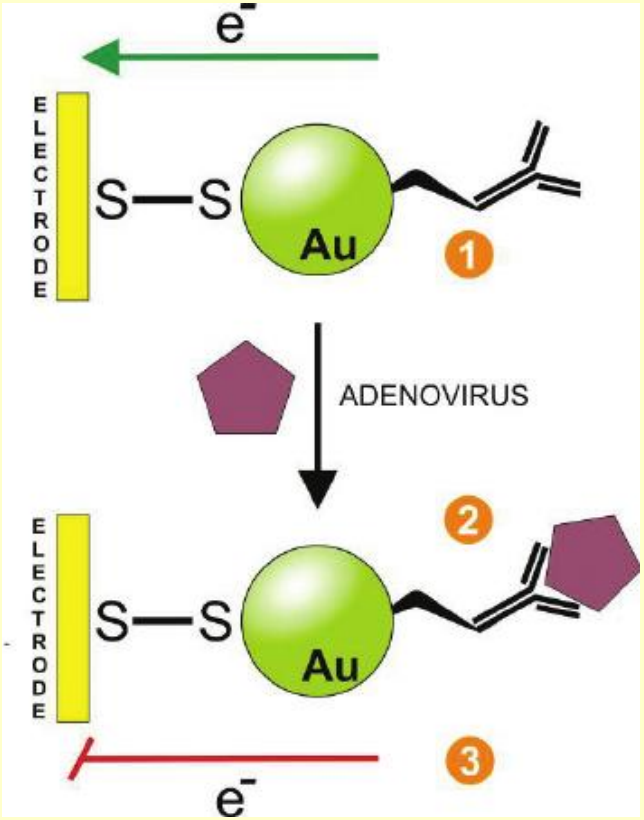
-Kinetic Parameters

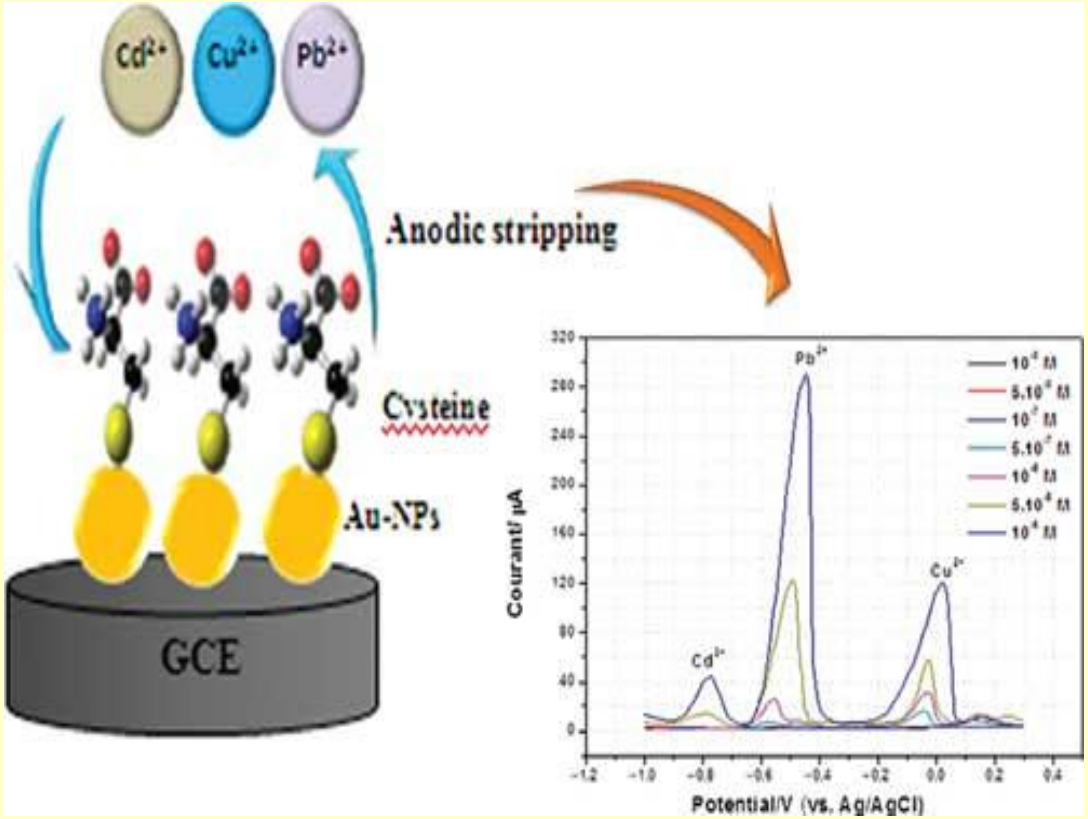
-standar rate constants of electron/ion transfers; kinetics of enzymatic reactions; kinetics of chemical reactions; ***pharmakokinetic parameters...***



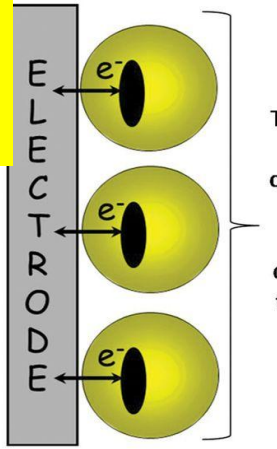


Voltammetry-NANOPARTICLES MODFICATION -new way of improving electrochemical signals-

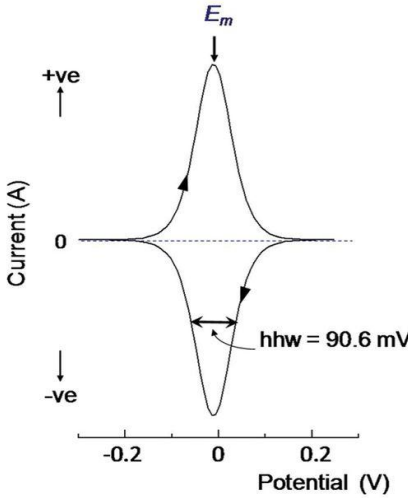


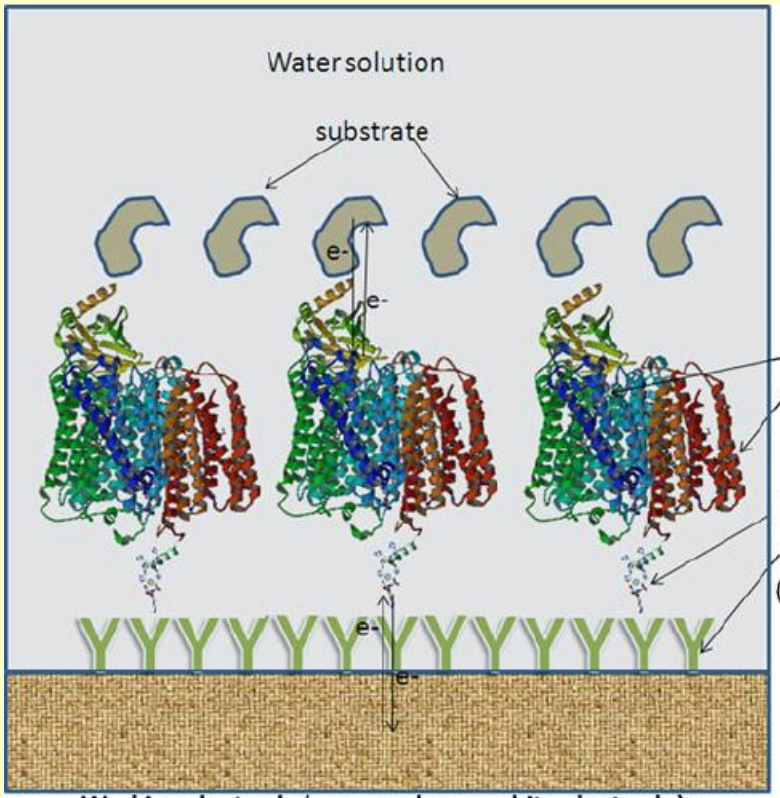


PROTEIN-FILM VOLTAMMETRY
Enzymes-Redox Chemistry



The adsorbed protein film can be placed in solutions of different composition, temperature etc.



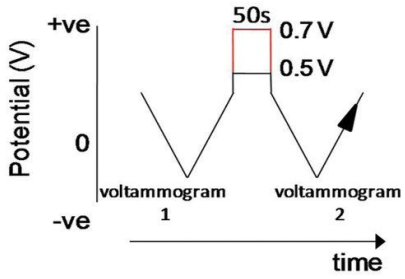


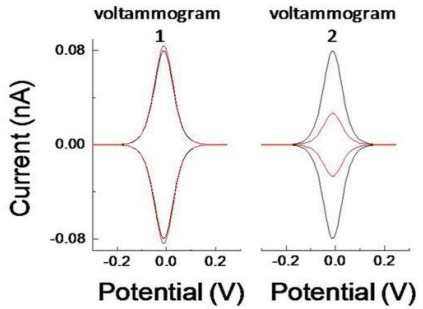
insulating parts of the protein

Protein redox active site

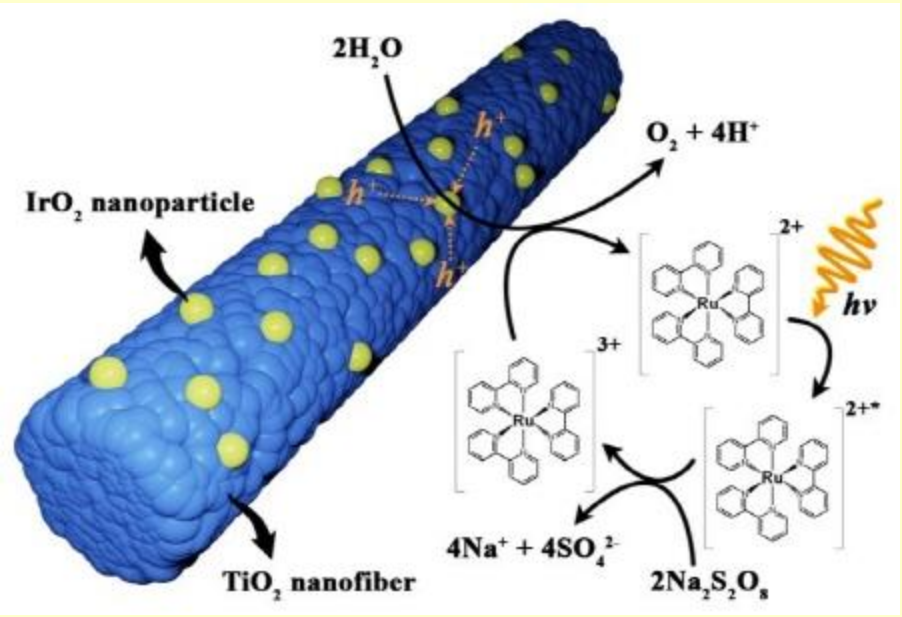
Modifiers of the electrode surface (nano particles, conducting polymers)

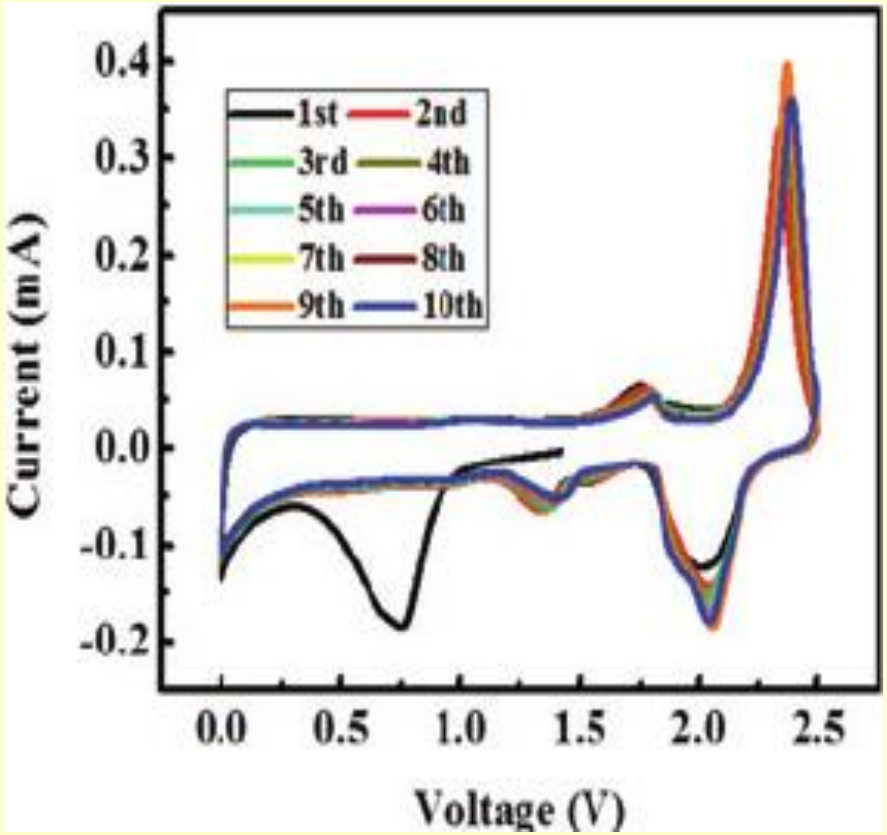
B



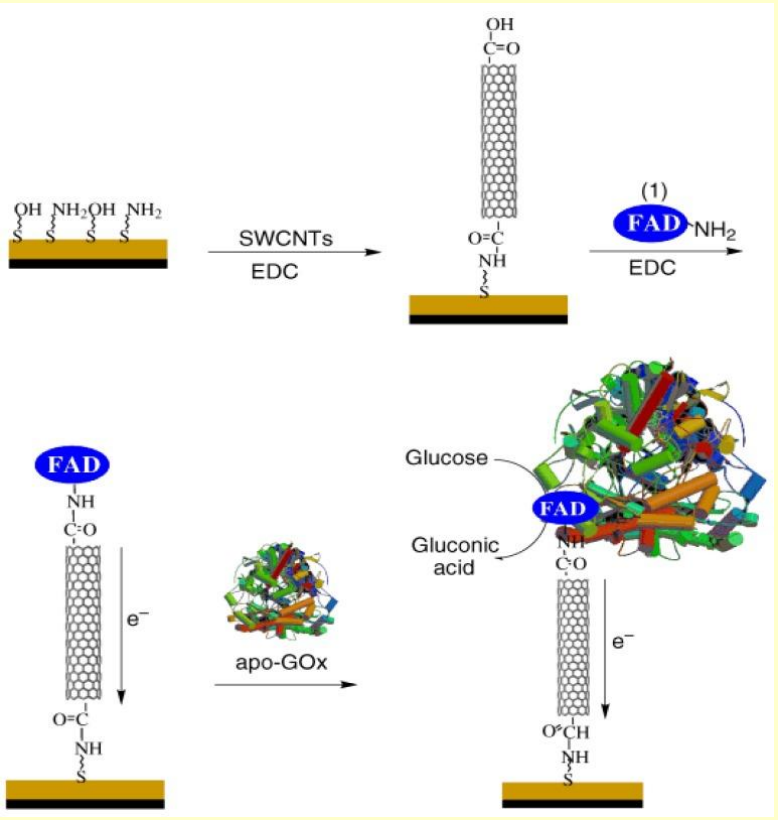


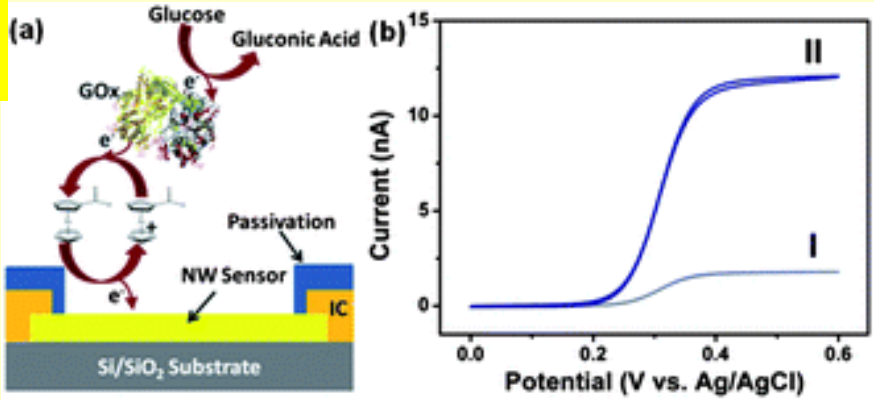
Voltammetry of BIOMATERIALS





Voltammetry is a tool for Designing BIOSENSORS





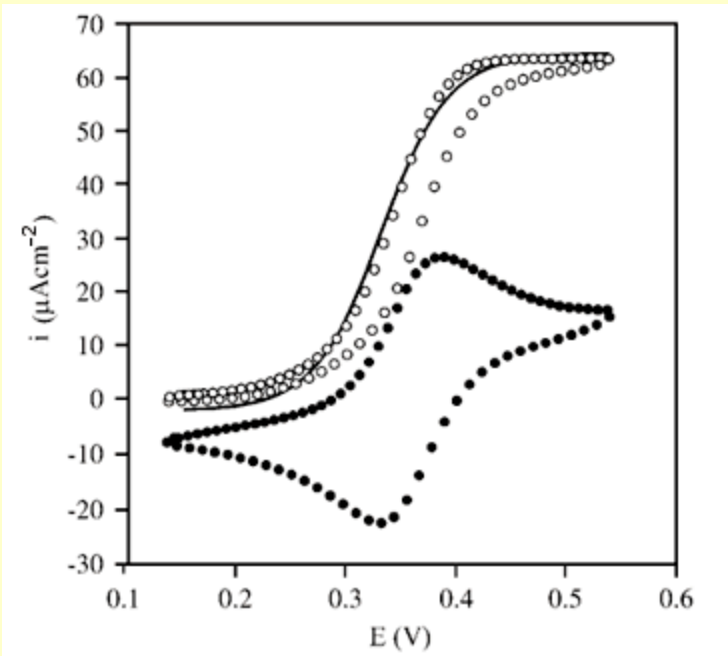
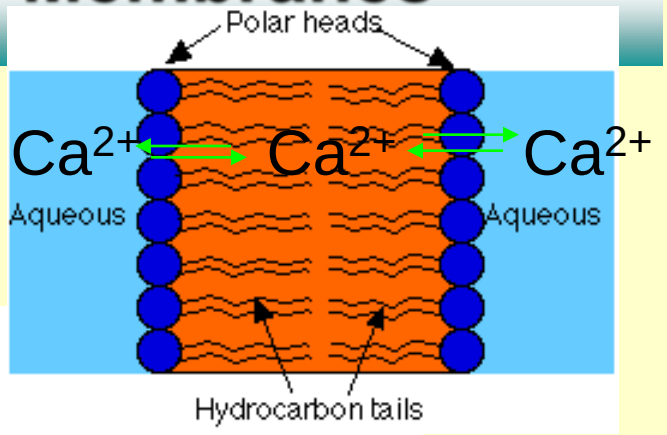
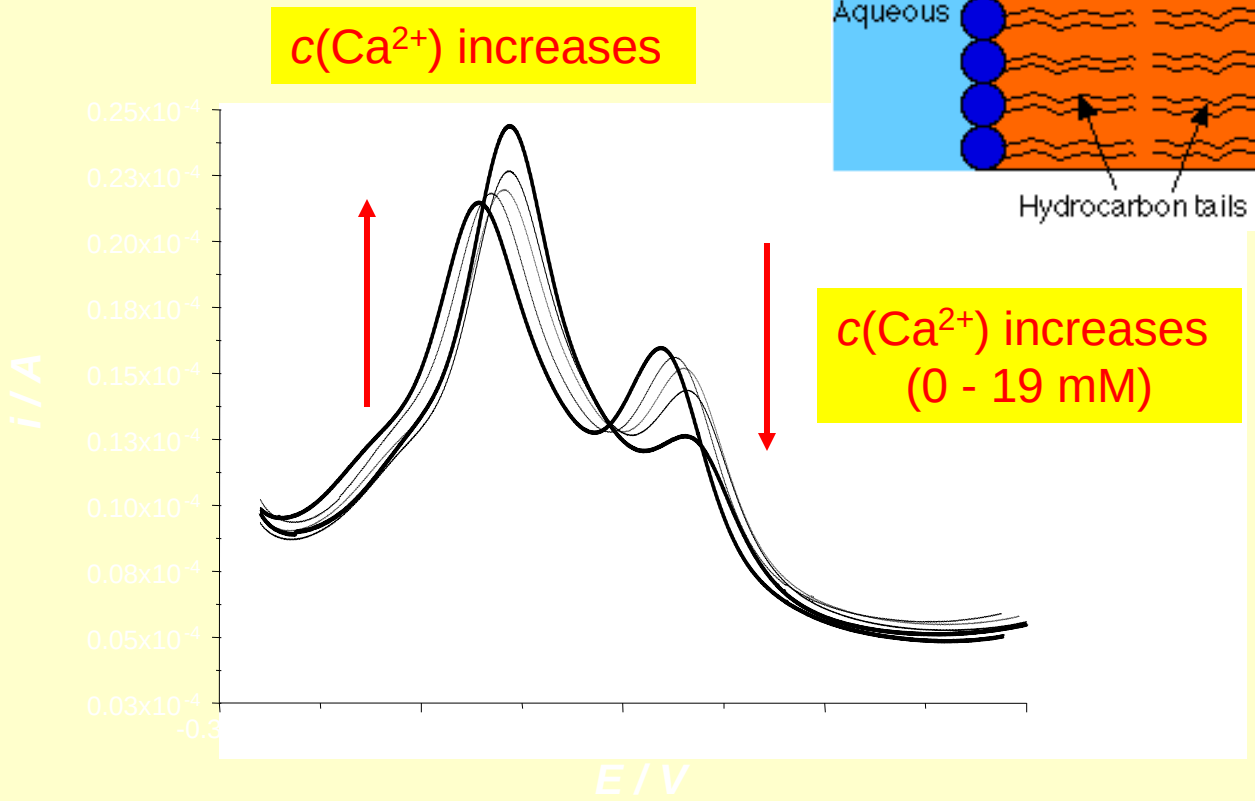


Figure 5. Catalytic wave for glucose oxidation in 50 mM phosphate buffer pH 7.1 and 0.1 M KNO_3 at a Fc-PAA-GOx hydrogel modified electrode (•) glucose free solution 10 mV s^{-1} and (o) 0.1 M glucose solution 5 mV s^{-1}. Solid line corresponds to best fit to Eq. 8. (see text).

Transfer of Ions Across Membranes

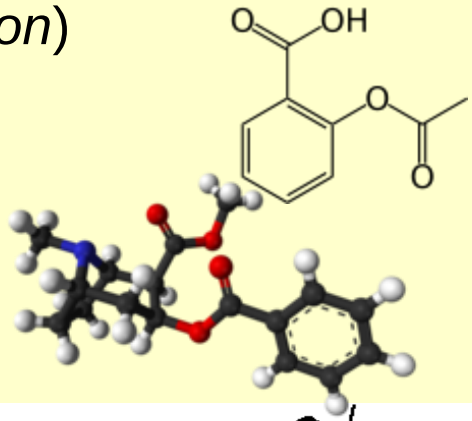


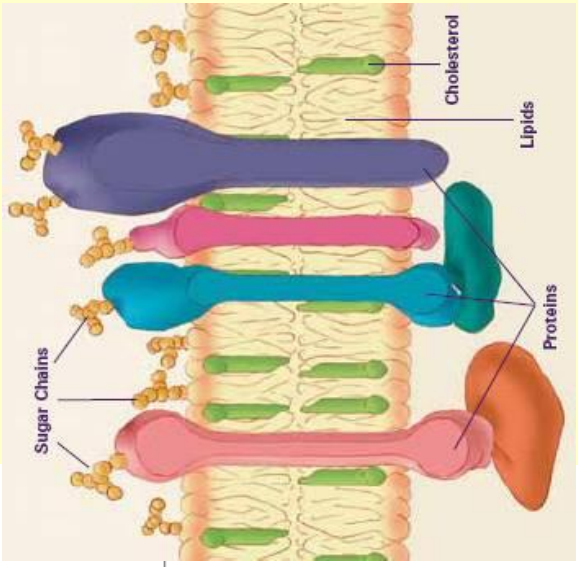


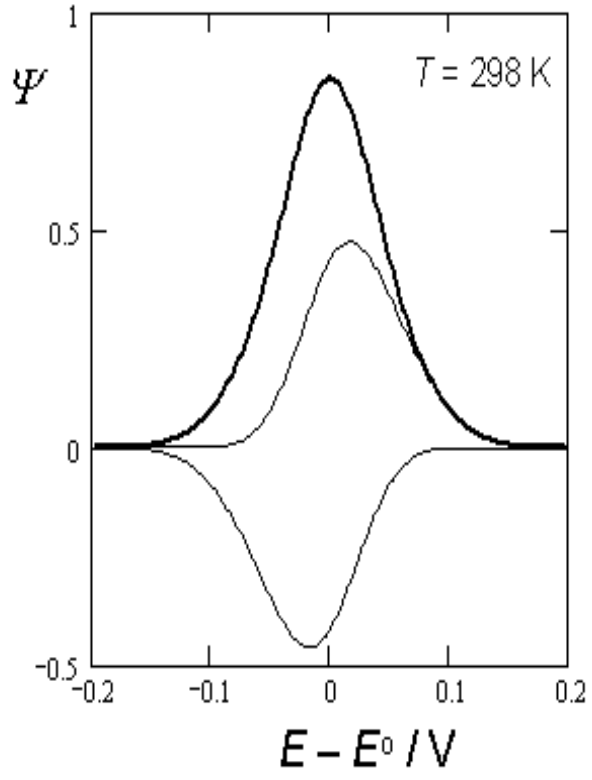
Cyclic voltammograms showing complexation of PalmytoilQuinone with Ca^{2+}

-***physical phenomena taking place in the system*** (*absorption, phase transformation*)

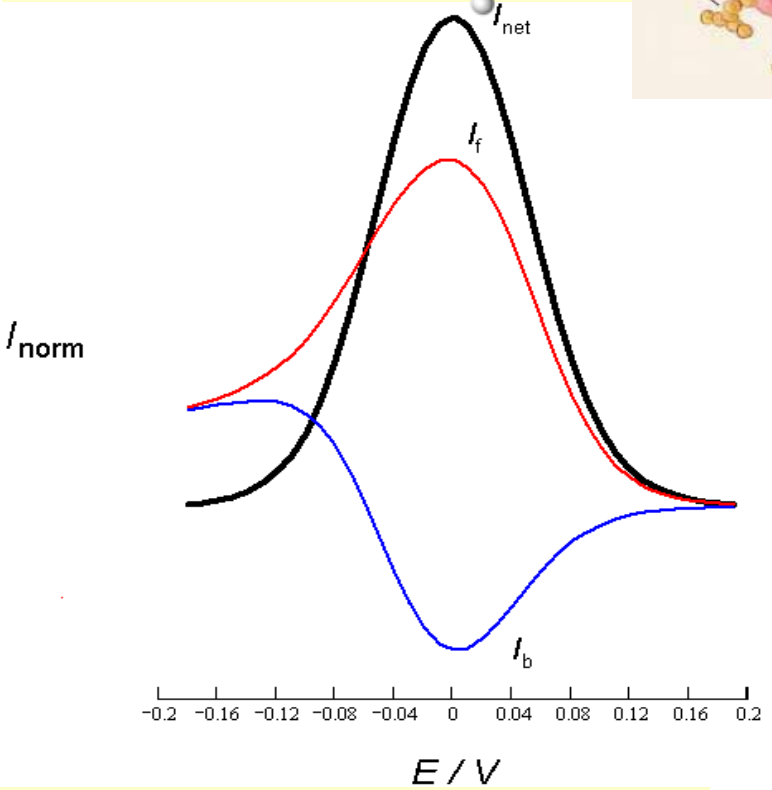
-way of mass transfer



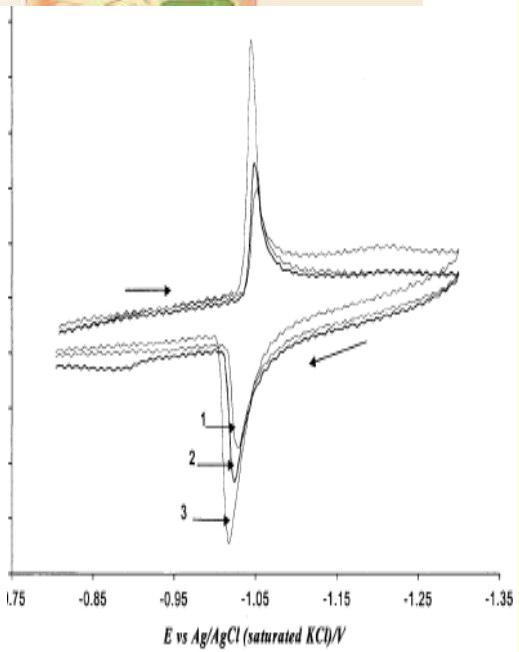




absorption



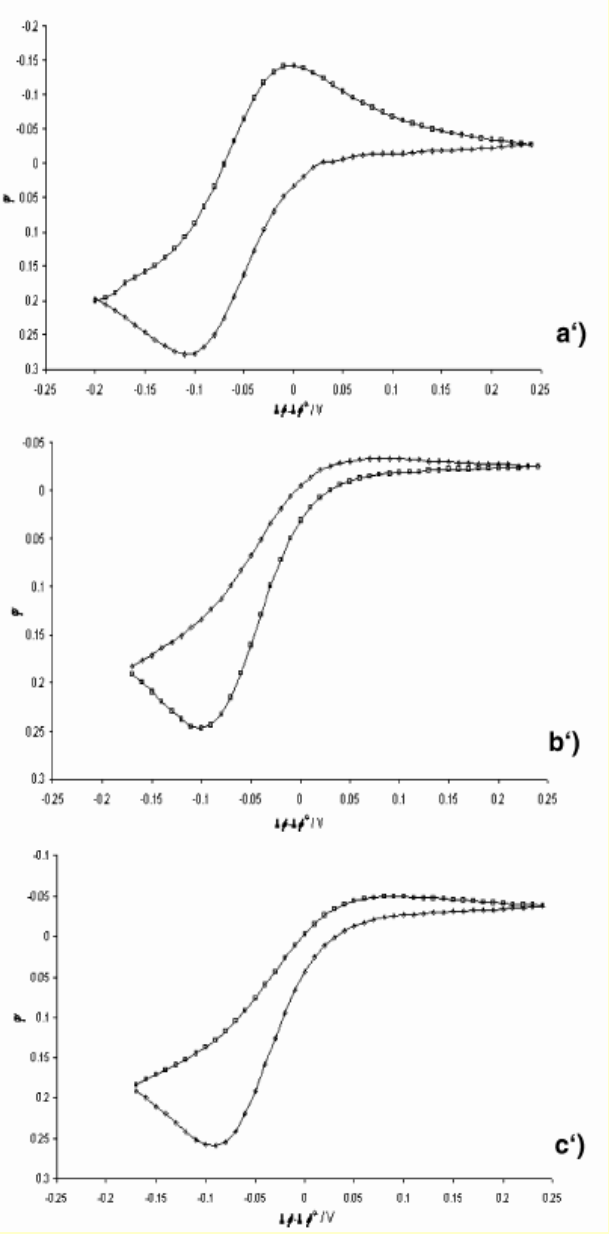
diffusion

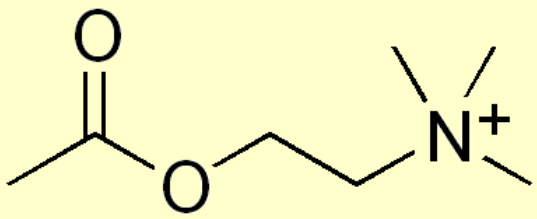


Phase-transformation

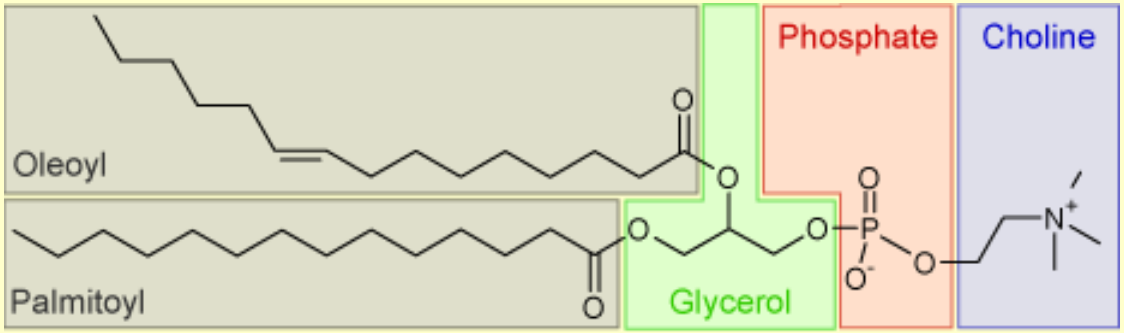
-thermodynamic and kinetic parameters related to the physical phenomena

-Strenghts of interactions between various substances





Acetylcholine



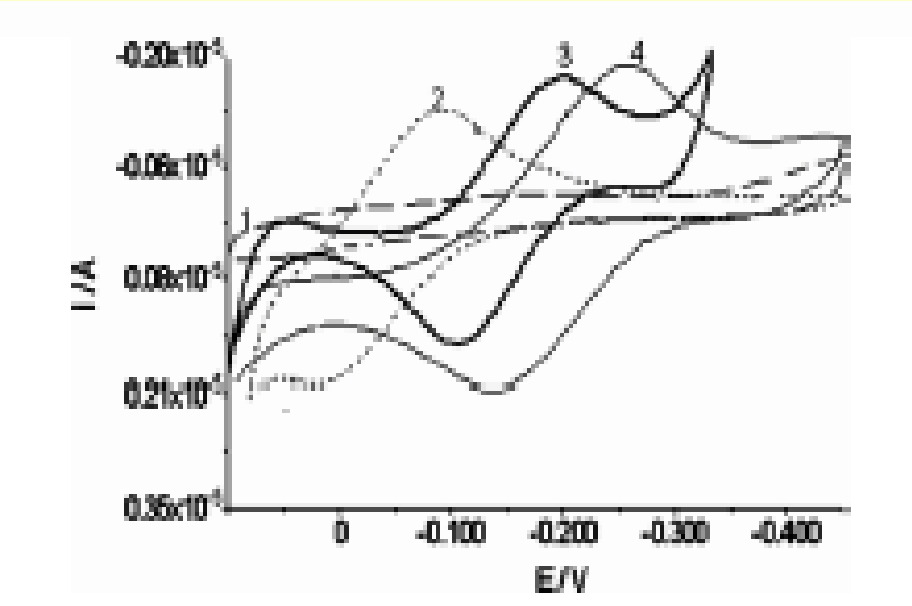
Phospholipids

TABLE 1: Determined Kinetic Parameters of the Ion Transfer of AcH^+ from Water to DCE (k_s and α) and for the Interactions between AcH^+ and DOPC (K, ϵ, k_f, and k_b)

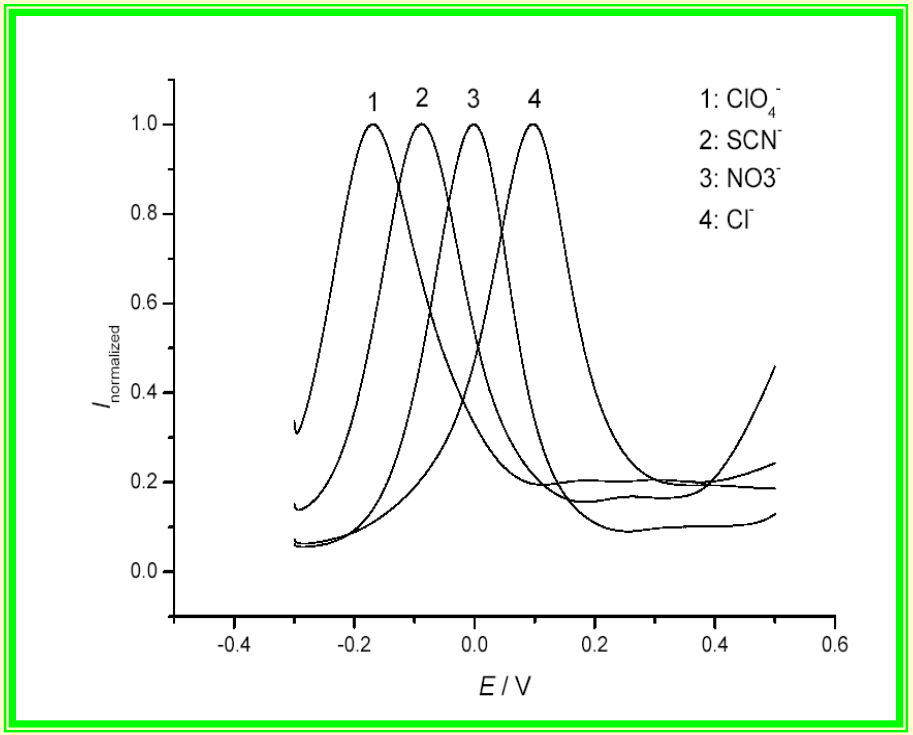
measuring technique	k_s/cm s^{-1}	α	K	ϵ/s^{-1}	k_f/s^{-1}	k_b/s^{-1}
SWV	0.0030	0.50	0.44	13.10	4.00	9.10
EIS	0.0033	0.53	0.80	13.30	5.90	7.40

Is it possible to investigate only the "electron" transfer reactions with Voltammetry?

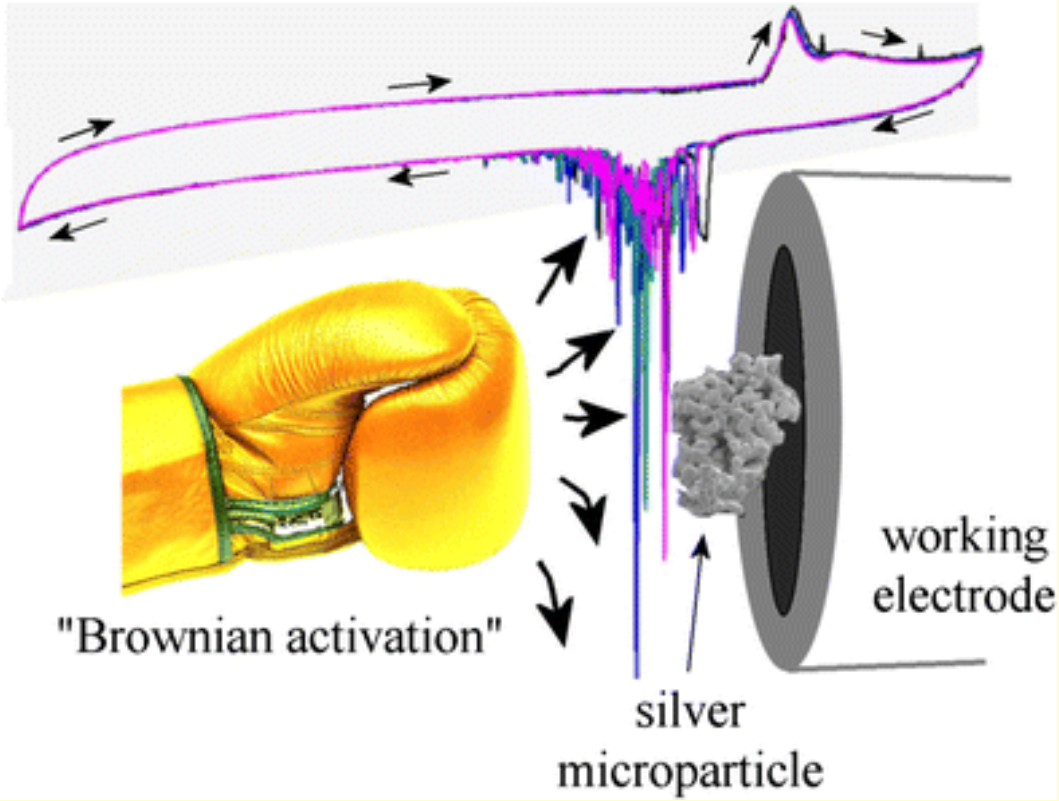
NO, it is possible to follow voltammetrically also reactions comprising only ION transfer, or COUPLED ELECTRON-ION transfer

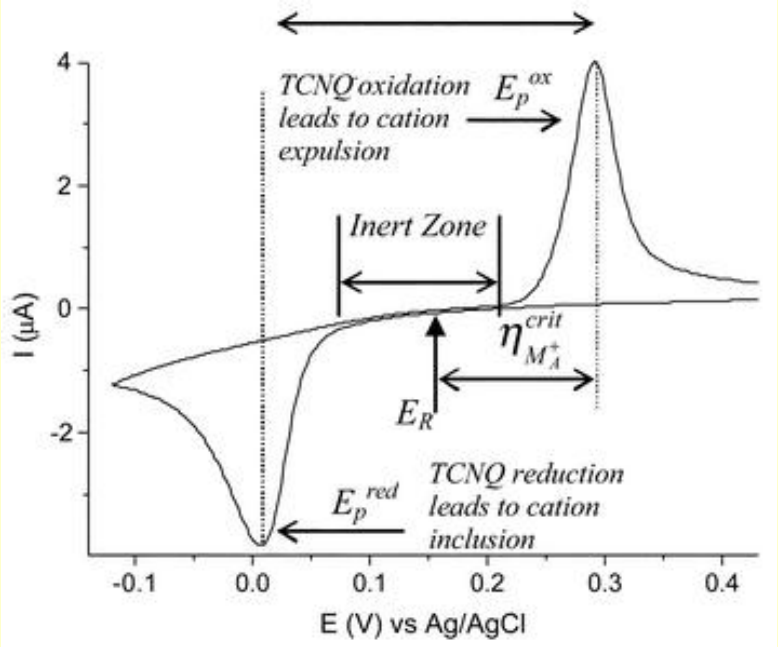


Transfer of Ionized Drugs-
heroin, cocaine and codeine
across biomimetic membranes



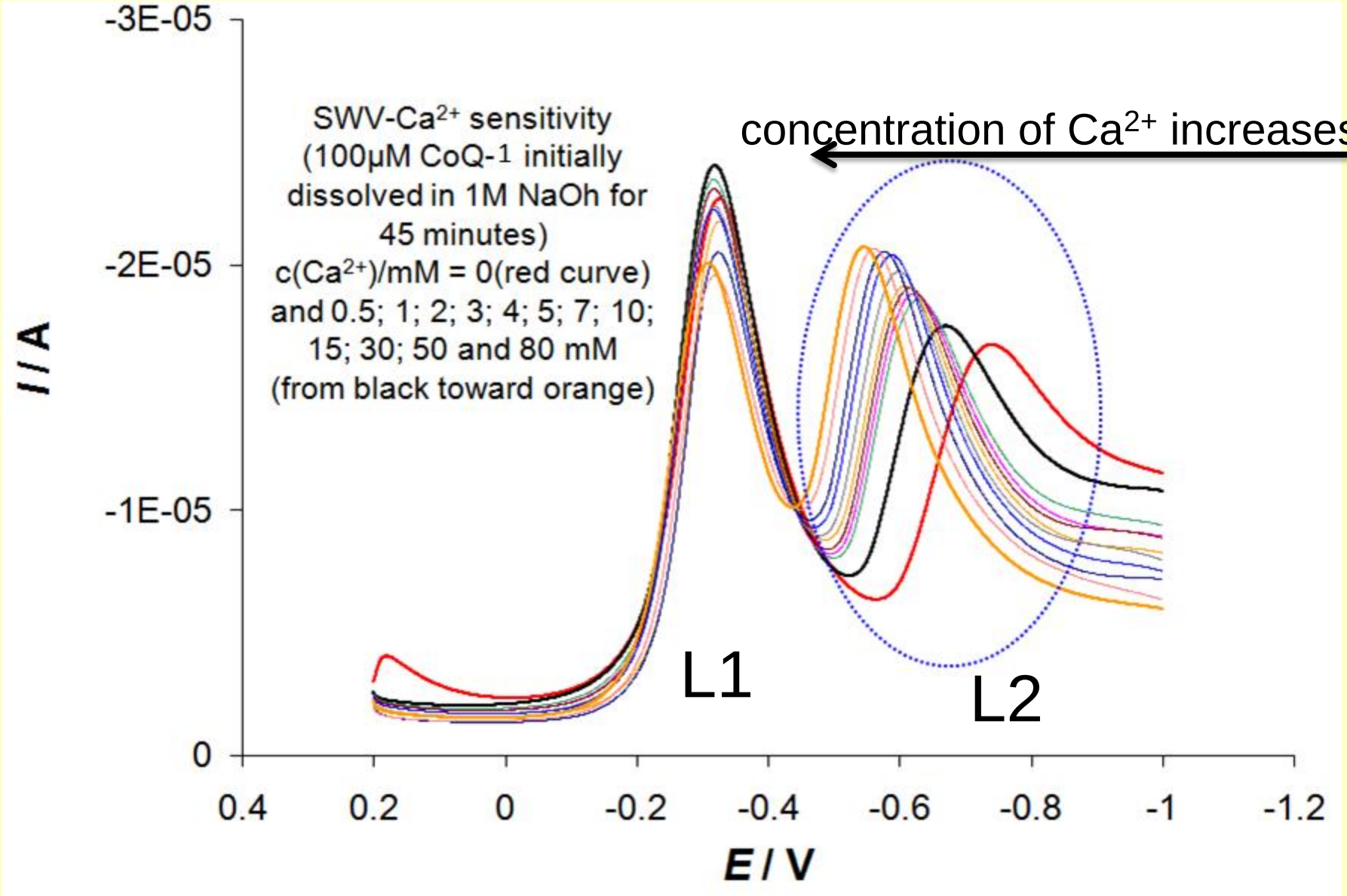
Voltammetry from Solid State

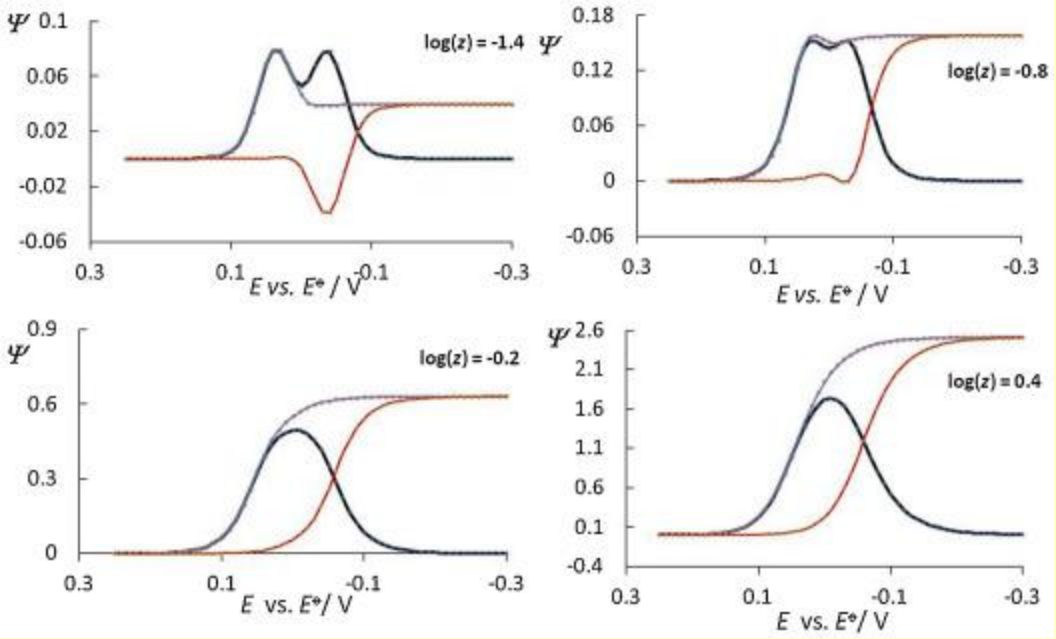


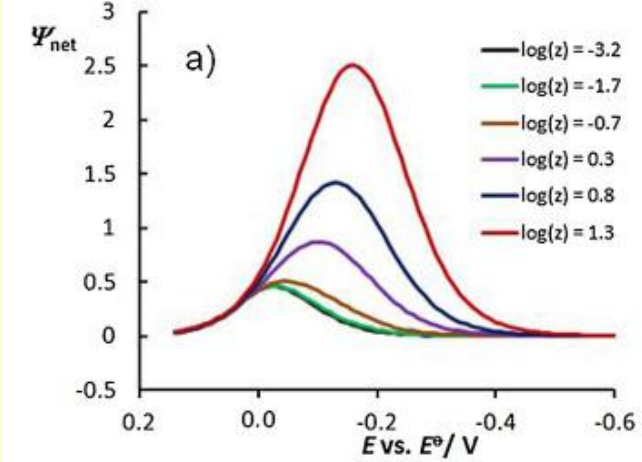


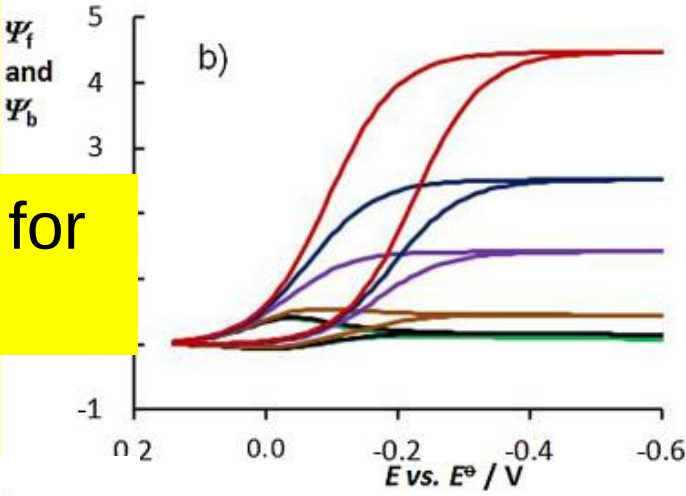
Pioneered by prof F Scholz

Complexation reactions.....

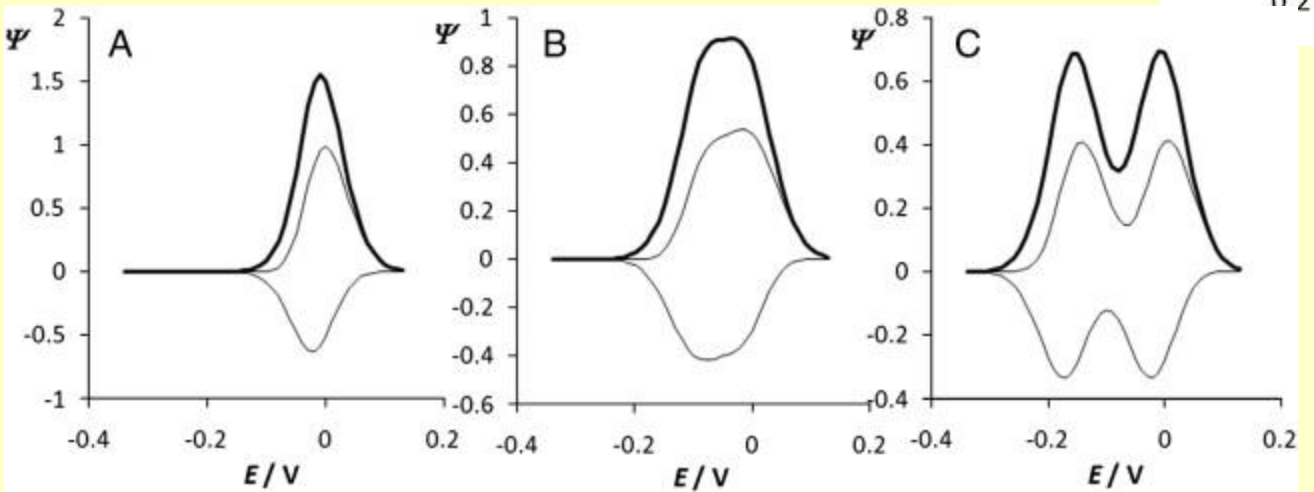








Well-Developed Theories in Voltammetry for Various Redox Mechanisms



Concluding remarks

...ADVANTAGES of using Voltammetry for characterization of biomaterilas:

-fast înstrumental technique

-extremely cheap instrumentation

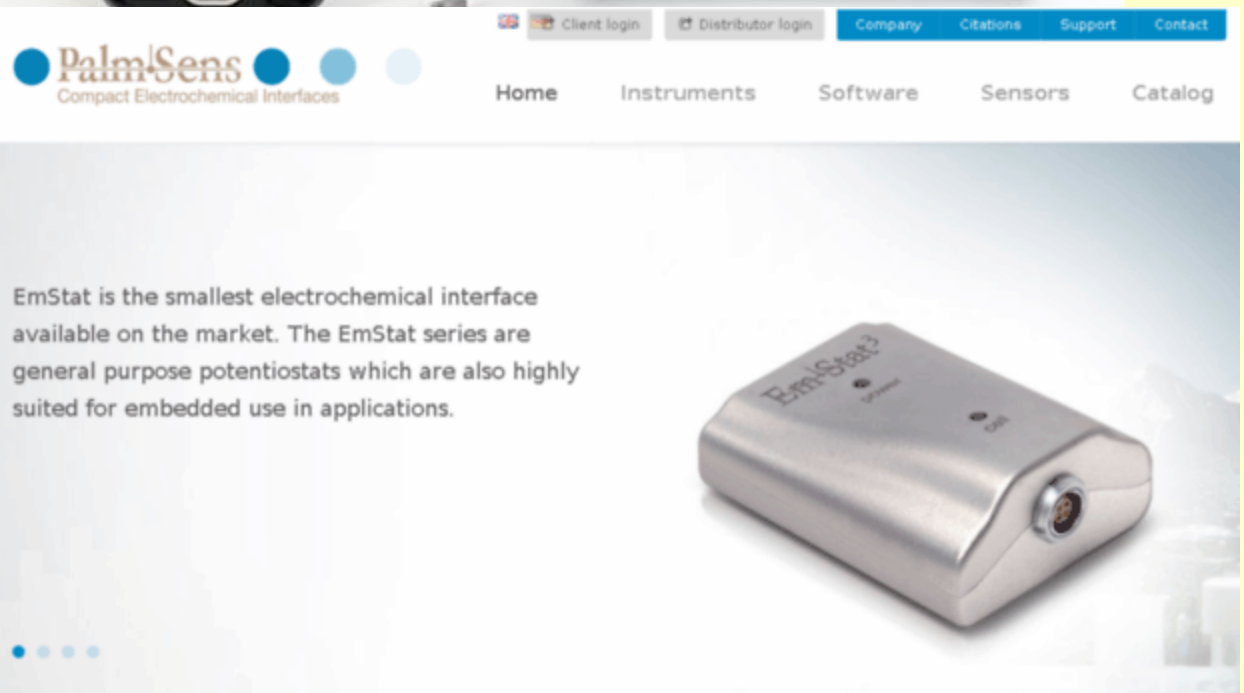
-common chemicals are used available in every Lab

-...suitable for qualitative, quantitative studies, Mechanistic studies, kinetic and thermodynamic measurements

Total costs for the voltammetric instrumentation

3-4000 Euros!!!!

Amazing!!! ONE CAN MAKE GREAT SCIENCE WITH Small AMOUNT OF MONEY!!!!!

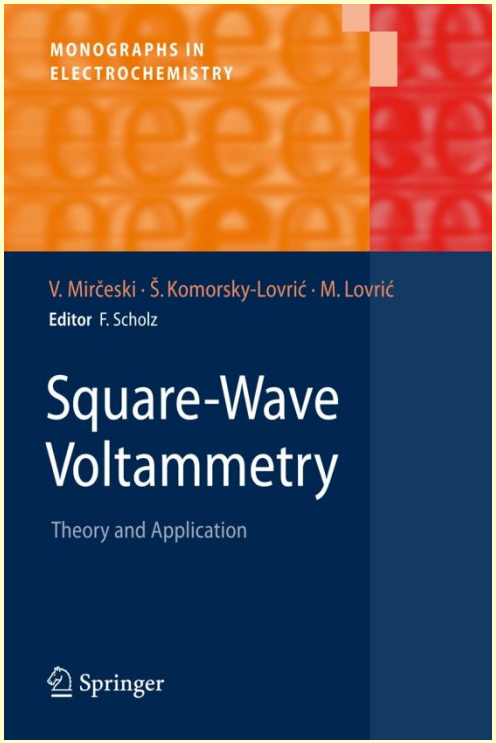


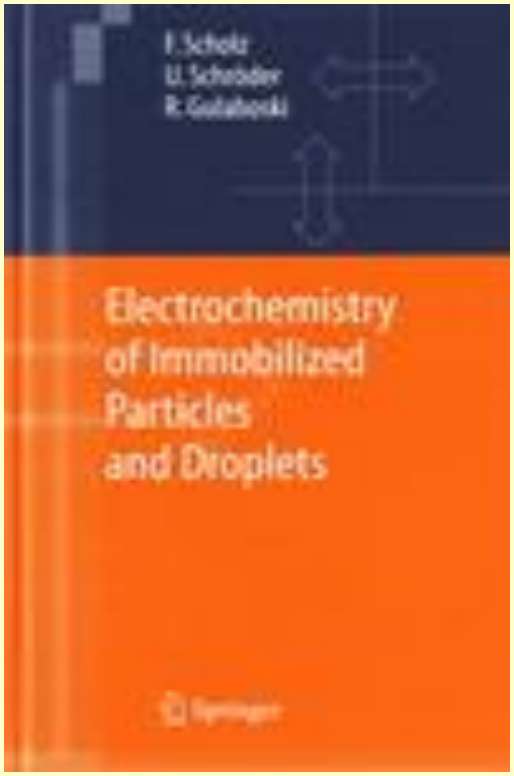

ZDE PŮSOBIL
V LETECH
1919 - 1950
PROFESOR
JAROSLAV
HEYROVSKÝ
NOSITEL NOBELOVY
CENY ZA CHEMII

What did I lose?
and

What did I get

From AvH and DAAD

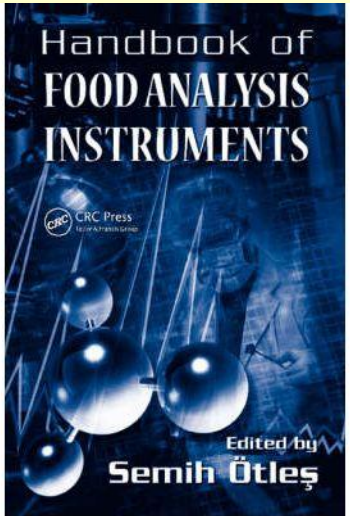




ELECTROCHEMICAL DICTIONARY (2008)
A. J. Bard, G. Inzelt, F. Scholz (editors)

F. Scholz, U. Schroeder, **R. Gulaboski**

R. Gulaboski, C. M. Pereira in
Handbook of Food Analysis Instruments (2008)
Semih Otles (Ed.)



But...this is the bigest POWER of Voltammetry

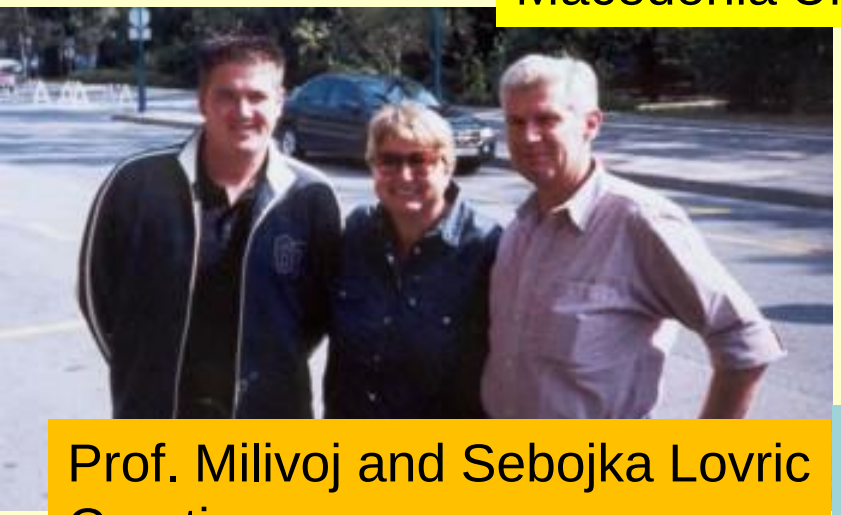
Prof. Fritz Scholz
Greifswald University

Prof. Valentin Mirceski
Macedonia University

Prof. Markus Hoth
Saarland University

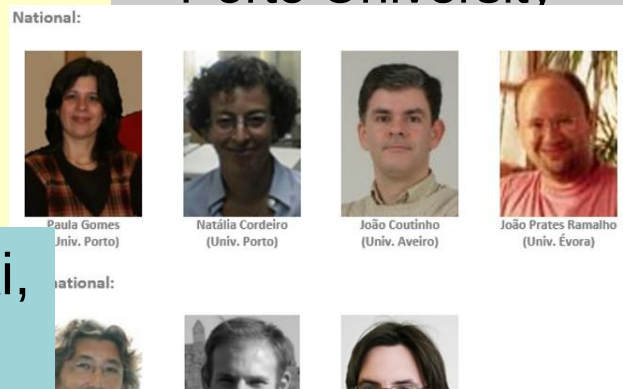
Prof. Reinhard Kappl
Saarland University

Prof. Carlos Pereira
Porto University



Prof. Milivoj and Sebojka Lovric
Croatia

Prof Ivan Bogeski,
Goettingen UNI



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I. Bogeski-Germany
K. Kumerow-Germany
S. Pasteka-Germany
B. Hoth-Germany
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